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A STUDY OF SPOTTED OWL HOME-RANGE SIZE AND COMPOSITION IN THE SIERRA NATIONAL FOREST

by

Donald L. Neal, Jared Verner, George N. Steger, and Gary P. Eberlein
Pacific Southwest Forest and Range Experiment Station
Fresno, California

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INTRODUCTION

This report summarizes key activities and results of field studies of spotted owls in the Sierra National Forest during 1988, occasionally relating them to comparable results from 1987. Our current planning calls for these studies to continue for at least 3 more years, contingent upon funding. However, the location of the field work may be shifted to the northern portion of the Sierra National Forest for the final 2 years.

OBJECTIVES

The principal objectives of the spotted owl research being done by the Pacific Southwest Forest and Range Experiment Station (PSW) work unit at Fresno are to:

1. Determine the sizes and extent of overlap of home ranges of pairs of radio-tagged spotted owls during the breeding season, and characterize the structure and composition of the vegetation included within their home ranges.
2. Determine the timing and extent of altitudinal migration exhibited by radio-tagged spotted owls.
3. Determine the sizes and extent of overlap of home ranges of individual spotted owls during the nonbreeding period, and characterize the structure and composition of the vegetation included within the home ranges.
4. Determine breeding activity, monitor breeding success, and color-band all offspring produced.
5. Document sources of mortality among spotted owls.
6. Characterize diets from collections of cast pellets.

STUDY AREA

The study area is located about 45 miles (72 km) northeast of Fresno, California, within the Sierra National Forest, in the watersheds of the San Joaquin River and the North Fork of the Kings River. Vegetation at the lower elevational limit of the summer ranges of spotted owls radio-tagged in this study is dominated by Ponderosa pine (Pinus ponderosa); at the upper limit, it is dominated by white fir (Abies concolor) and red fir (A. mangnifica). Much of the area was logged between 1880 and 1930 and much of the old-growth coniferous forest is in remnant stands. Timber harvest at a reduced rate has continued on National Forest lands and small parcels of private lands within National Forest boundaries. Active regeneration programs have been in place in recent years on these lands.

Areas to the south and west of the conifer-forest sites that may be used by spotted owls during the winter, at elevations from about 800 to 3000 ft (245 to 915 m), are dominated by blue oak (Quercus Douglasii), digger pine (Pinus sabiniana), and various foothill chaparral species.

METHODS

Capture

Insofar as possible, owl pairs were captured in a cluster of birds thought to have adjacent home ranges, so the extent of overlap could be determined. We had more difficulty capturing birds for the first time in 1988 than in 1987, and the challenge was even greater when recapturing birds with inactive transmitters. Spotted Owls in the Sierra National Forest tend to roost very high in trees, where they are inaccessible for noosing. One sick bird was

recaptured with a noose pole. All other birds captured in 1988 were lured to the ground with tethered mice; responsive birds were either caught in mist nets or with fish-landing nets. No injuries to birds or capture personnel occurred during these operations.

Radio-locating birds

The transmitters used on birds in 1988 were of two types: (1) Telonics Model 70*, weighing 22 g. Backpack attachment materials added another 4 g, for a total of 26 g. (2) AVM Model P2, weighing 20 g; the total package with backpack attachment weighed 24 g. Receivers were Telonics Models TR-2 and TR-2 with Model TS-1 scanners attached. Vehicles were equipped with 5/8-wavelength, base-loaded, roof-mounted, whip antennae for omni-directional searches. Directions to birds were determined using Telonics RA-2, two-element, Adcock hand-held antennae and Suunto KB-14-360R, hand held compasses. If a bird could not be located by normal ground search methods, an airplane was used to search for the transmitter signal.

After several birds were captured and radio-located a few times, and the extent of their home ranges had been estimated, about 150 semi-permanent triangulation stations were located and marked on the ground at selected, convenient locations within home ranges and along their perimeters. Each triangulation station was precisely located on small field maps and on large-scale (1:24,000) topgraphic maps with the universal transverse mercator (UTM) grid drawn on them.

Most locations were done by single observers, although in difficult situations we attempted to obtain vectors simultaneously from two observers using two stations. When only one observer was available they had to move quickly from one station to another to reduce the chance of bird movement between observations. Vectors to the bird from at least three stations were taken before the location was recorded. If the three vectors did not cross within 100 m, radio vectors were taken from additional stations until three crossed within the 100-m limit. The bird is recorded as being "located" in the center of the polygon formed by all vectors. If any other factor, such as excessive time between vectors, signal strength, or unusual habitat at a location caused the observer to question the vectors, more were taken from the same and additional points until the observer was satisfied with the accuracy of the bird's indicated location.

Determination of habitat used requires more precise radio-locating of birds than determining home-range boundaries. Therefore, after each radio-location, the observer estimated the accuracy of the location based on radio signal and size of the vector-formed error polygon (the area enclosed by three intersecting vectors). This was used to classify locations as (1) valid for determining habitat use and home-range boundaries, or (2) useful only for delineating home-range boundaries.

For each observation, the bird, date, time, weather, and all triangulation points and vectors, were recorded on a preprinted 5- x 8-inch field form. Each week's forms were delivered to the Fresno Laboratory, where the data were entered into the Data General computer terminal via a custom format using screen prompts and some simple error-check routines. Data were then plotted and examined for suspicious bird locations. When questionable locations were found, the field forms were examined to determine whether a recording error could be identified. If the problem could not be resolved, the cards were

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* Mention of trade names is for information only and is not an endorsement of any product by the government.

returned to the field and discussed with the person(s) making the observation. The problem could usually be resolved this way.

Diet

Diets of spotted owls in the Sierra National Forest are being determined from examination of cast pellets collected as time permits. Roost and nest areas were cleaned of old pellets, and pellets were collected each time an observer was in the area throughout the season. Pellets were bagged and labeled with the date of collection and number of the bird or pair of birds using the area. By 31 December 1988, 664 pellets had been collected and 320 had been analyzed by personnel at the Redwood Sciences Laboratory in Arcata to determine the prey species comprising owl diets in our study area.

Habitat descriptions

Using seasonal home-range boundaries delineated according to the minimum convex polygon model, a vegetation-type matrix within each summer home range delineated in 1987 was mapped on large-scale aerial photos, delineating each type polygon. Preliminary ground checking of the aerial PI work has been completed on these home ranges; this effort did not involve much actual measurement of habitat variables. Data have been analyzed to assess habitat preference. This work remains to be done for the 1988 breeding season and for winter home ranges in 1987/88.

Six habitat types have been distinguished for the present analysis, as follows:

1. High-Density Conifer Forest (HDCF). All conifers with a dbh of at least 5 inches combine to a canopy closure of at least 70%. Quantities of understory vegetation, litter, and exposed soil were not distinguished. The average site in this type had 31% of the canopy in trees at least 20 inches dbh and 40% of the canopy in trees smaller than that, for a total of 71% canopy cover.
2. Mid-Density Conifer Forest (MDCF). All conifers with a dbh of at least 5 inches combine to a canopy closure of 40-69%. Quantities of understory vegetation, litter, and exposed soil were not distinguished. The average site in this type had 19% cover in trees at least 20 inches dbh and 32% in smaller trees, for a total of 51% canopy cover.
3. Low-Density Conifer Forest (LDCF). All conifers with a dbh of at least 5 inches combine to a canopy closure of 0-39%. Understory vegetation cover was estimated and used in this classification. The average site in this class had 7% cover in trees at least 20 inches dbh and 17% in smaller trees, for a total of 24% canopy cover.
4. Meadow. At least 45% of the understory vegetation was grass or herbaceous material, normally associated with wet and dry mountain meadows. All tree size classes could be present, but with no more than 39% canopy cover.
5. Shrubfield. At least 50% of the understory was dominated by woody species less than 10 feet tall. All tree size classes could be present, but with no more than 39% canopy cover. Conifer plantations were included in this type if shrubs dominated or trees were less than 10 feet tall.
6. Rock Outcrop. At least 50% of the ground surface was bare rock, usually as granitic outcrops. All tree size classes could be present, but with no more than 39% canopy cover.
7. Shrub/Rock. Neither shrubs nor rock outcrops met criteria for types 5 or 6, but together they comprised at least 60% of the surface area in

this type. All tree size classes could be present, but with no more than 39% canopy cover.

Nearly all habitat polygons of all of these types had remnants of old-growth forest from the early days of logging in this part of the Sierra Nevada. The general forest matrix is essentially a mixture of young and mature timber with old-growth inclusions.

RESULTS

Capture

Ten birds had active transmitters on 1 January 1988; these represented seven known pairs. Seven new birds were transmittered during the calendar year; transmitters were replaced on 5 birds, and only six birds had active transmitters by 31 December 1988 (Fig. 1). All captured birds appeared healthy and normal, although most had large numbers of external parasites, mostly hypoboscid flies, as in 1987. Bird codes refer to the general areas in which they were initially captured.

Breeding activity

We found no evidence of breeding in 1988, a result supported by the inventory and monitoring work of personnel on the Sierra National Forest. We do not know the reason for this, although we had unusually low success in capturing small mammals for the "mousing" work. This makes the second consecutive year of no breeding by birds in our study area, and it was also the second consecutive year of a significant drought in California.

Transmitters and radio locations

Generally, both the Telonics and AVM transmitters performed about the same for triangulating locations of spotted owls. However, eight of nine Telonics transmitters attached in both 1987 and 1988 exceeded their specified life of 9 months, but 6 of 11 AVM transmitters failed before the specified life of 13 months (mean life of those 6 was about 7 months; range = 127-319 days).

We obtained 1826 radio locations on a total of 19 birds in 1988, or an average of 96 locations per bird. We obtained at least 100 summer-range locations on four birds and nearly that number on two others. And we obtained at least 100 winter-range (1987-88) locations on two birds and nearly that number on three others.

Seasonal variation in home-range occupancy

As in 1987, some birds migrated to disjunct winter ranges at lower elevations and some did not. We perceive four patterns that seem worth differentiating among owls in the Sierra National Forest: (1) permanent residents use essentially the same home ranges during winter and summer (Figs. 2-5); (2) like permanent residents, "enlargers" use the same area in winter as used in summer, but the winter area is larger than the summer area (Fig. 6); (3) "shifters" just shift their home range in the winter, maintaining some overlap with the summer home range (usually the shift is downslope in winter, but one bird shifted upslope) (Figs. 7 & 8); and (4) altitudinal migrants occupy distinctly different home ranges in winter from those used in summer (Figs. 9-11). In all cases, winter home ranges of migrants were at lower elevations, in oak-pine woodlands with interspersed shrub- and grasslands. Forty-four percent of the birds in our sample over a 2-year period were permanent residents, 28% were migrants, 17% were shifters, and 11% were enlargers. No bird changed its pattern between years.

The Stevenson female was the first to begin spring migration, as she began to move back to her summer home range on 3 March 1988; her mate did not begin to return until 30 March. Dinkey Male 2 began spring migration on 7 March. Markwood Female 2 was the first to begin fall migration to her lower-elevation, winter home range, on 8 November 1988. The Stevenson Female headed downslope on 12 November, and the only other migrant with an active radio--the Strawberry Female--began moving down on 1 December.

We have no clear evidence about factors that may trigger migration. The limited data available suggest that birds with summer home ranges at higher elevations are more likely to migrate than those at lower elevations, although both member of the Exchequer pair are nonmigrants and they have one of the highest home ranges. Some birds migrated before winter conditions, and even the first snowfall, and others migrated long after the first heavy snowfall. Some birds migrated but their mates did not. And some moved downslope to occupy in the winter the summer home ranges of other birds that migrated further down.

Home-range size

Results reported here are based on 1987 and 1988 field work to allow a comparison between years (Table 1). Summary statistics indicate summer home ranges averaging between 2500 and 3200 acres, with medians of about 2300 acres (Table 2). The median values are probably more meaningful, as some means are considerably exaggerated by samples including one unusually large home range (samples for full year and winter of 1987-88). Winter home ranges of nonmigrants averaged about 3100 acres in 1987-88 (data for 1988-89 are incomplete at this time), with a median of about 4000 acres (Table 2). Full-year home ranges of nonmigrants averaged 6095 acres (n = 9; range = 2861-15,713 acres; median = 4708 acres). For these analyses, "summer" has been defined as the 7-month period from 1 March to 30 September, approximately corresponding to the period during which the birds would be nesting and caring for dependent young. The "winter" period covers the remaining 5 months.

The mean and median home ranges of males in summer were smaller than those of females, but four of seven females had smaller home ranges than their mates (Table 3). Mates shared about 37% of their summer home ranges with each other (Table 3 and Figs. 12A-12H), and the combined home ranges of mated birds averaged 4102 acres (median = 3770 acres). Until birds in our study area nest and produce young, we cannot determine whether home ranges in this size range are sufficient for reproduction.

As in 1987, summer home ranges of all birds (neighbors as well as mates) in 1988 exhibited much overlap by the time sufficient numbers of locations were obtained. To estimate the "exclusive" area per bird, we determined the area included within the contiguous home ranges in our study area for the summer period of 1988. In four cases we had to use 1987 summer home ranges for radioed birds with inactive transmitters in 1988 that were, nonetheless, observed regularly in 1988 in the same areas used during summer 1987. Computing crude density from the aggregate of these summer home ranges gave an estimate of only 2014 acres/bird (see Fig. 13). This compares with a mean home-range size of 3675 acres for the summer of 1988, suggesting that at least 45% of the birds' summer home ranges overlapped home ranges of other birds. In addition, we know that one of the radioed birds had an unradioed mate using the same general area. Allowing for the unradioed bird brings the mean area/bird to 1888 acres, and the proportion of home ranges overlapping to 49%. (This translates to an estimate of crude density of 0.34 owls/mi^2). Furthermore, this does not allow for portions of home ranges along the outer boundary of the aggregate area that are overlapped by home ranges of spotted owls not included

in our study. And it also does not allow for "floaters" (unmated, nonterritorial birds that must be finding existence habitat somewhere and that presumably replace mated, territorial birds that die. For example, the Markwood Female died during this sample period and was replaced by an unradioed bird at least within 3 weeks. Whether the replacement was living within our study area prior to forming a pair bond with the Markwood Male is unknown.

Mortalities

Four mortalities occurred during 1988 (Fig. 1). The Deep Creek Female died on about 11 July. Only feathers, transmitter, and leg band were found. The remains were in the open and no probable cause of death could be determined. She had carried a transmitter for 106 days. Dinkey Male 2 died on 11 May. He was recaptured on 4 April and a new transmitter was attached; his weight and all other signs were normal at that time. On 9 May he looked sick, so he was noosed and taken to a veterinarian in Fresno, who sutured an injury on an eye. He was then taken to an animal recovery center, where he would not eat. He died about a day later. Although this male carried a transmitter for nearly a year, he died only 37 days after having a replacement transmitter attached. He was obviously starving when he was noosed and taken to the vet (original capture weight = 524 gms; capture weight when the replacement transmitter was attached = 532 gms; weight when noosed = 370 gms--a 30.5% weight loss in 37 days), but we could not ascertain whether the eye injury contributed to his weight loss or if weakness from weight loss contributed to his eye injury. Laurel Male 1 died on 26 January, after carrying a transmitter for 226 days, a period that included migration. Only feathers, one wing, and the transmitter were found on a steep hillside in open digger pine woodlands. No probable cause could be determined. Markwood Female 1 died on 13 May; she had carried the original transmitter 345 days but died only 31 days after having a replacement transmitter attached. The whole carcass was found, covered with ants. No probable cause of death was determined.

Although four of 19 (21%) transmittered adults died in 1988, the true annual mortality rate was even higher. To estimate this, we tallied 5087 "owl-days" (any radioed owl known to be alive in our study area for 1 day) in 1988. This is equivalent to 14 owl-years. On that basis, we observed an annual mortality rate of 28.6% among owls wearing radio transmitters in 1988. And this is optimistic, because it assumes that all owls whose radios became inactive during the year, but that did not receive replacement transmitters, survived to the end of the year. We have no evidence to the contrary, and many of those birds have been seen frequently during the period after their transmitters ceased to function. The comparable value for 1987, based on number of owl-days, was 29.6%. Such a high, annual mortality rate cannot be sustained by a spotted owl population. We suspect that it reflects an effect of the radios and/or harnesses worn by the owls, and that it should not be considered normal for owls without radio transmitters.

Diet

Because we have spotted owls at both high elevations (mixed-conifer forests) and low elevations (oak-pine woodlands) during both winter and summer, we are seeking sufficient samples of pellets to characterize diets in both localities during both periods of the year. Current data sets allow preliminary analysis of diets only in summer at high elevations and in winter at low elevations (Table 4).

We identified 1048 individual prey items in 272 pellets from high elevation in summer. Numerically, small mammals were most abundant, insects were second, and birds were least abundant (Table 4). We have not had time yet to express

results in terms of biomass; however, it is evident that the relative importance of small mammals will be even greater when expressed as biomass, birds will be second, and insects last. Among small mammals, the northern flying squirrel (Glaucomys sabrinus) was most common and would be conspicuously more important in terms of biomass. Pocket gophers (Thomomys spp.) were second numerically and in biomass, and deer mice (Peromyscus spp.) were third in both respects.

We identified 73 individual prey items in 48 pellets from low elevation sites in winter. As with the summer samples, mammals were numerically the most abundant and undoubtedly comprised most of the biomass as well. In fact wood rats (Neotoma spp.) were by far the heaviest species in the sample, and they made up 73% of all individuals of all taxa identified (Table 4).

We often observered spotted owls foraging for insects, taking them from bark surfaces, from the ground, and even catching them in the air. In one instance, we were trying without success to lure a bird down for capture using mice tethered to a Cooper trap. It showed no interest in the mouse but occasionally chased flying insects. When we tethered a large moth to the center of the trap, the owl immediately swooped down to the trap. (She tripped the release cord with her wing before landing on the catch platform, however, so we still did not catch her.)

Habitat description

Except for Stevenson Male 1, MDCF was the predominant habitat type in the summer home ranges of all birds in 1987, averaging 59.2% of the total (Tables 5 & 6). HDCF comprised an average of only 12.4% of the home ranges, and LDCF averaged only 2.7% (although the "nonforested" habitats usually had some conifers and all would be in the LDCF type if not separated out as meadows, shrubfields, etc.). The pooled mean of the three conifer types in the 1987 summer home ranges was 1775 acres (Table 5). Combined areas of meadows, shrubfields, rock outcrops, and mixed shrub-rock habitat averaged about 719 acres (Table 5), or 27% of the home ranges (Table 6).

All but one of 11 birds exhibited patterns of habitat use significantly different from expected, based on availability (Table 6). HDCF stands were preferred, being used about twice as often as expected. However, on the average, the birds exhibited neutral use of MDCF and LDCF stands (Table 6). They generally used meadows, shrubfields, rock outcrops, and mixed shrub-rock habitats less frequently than expected from their availability. Among 36 comparisons of use vs availability (where availability was greater than zero), the 11 birds combined used these habitats less than expected in 32 cases and more than expected in only 4 cases ($P = 0.000001$), and use was less than half the expected in 21 of those cases.

Generally, data from the conifer-forest zone suggest that spotted owls prefer dense stands of mature conifer forest, most of which include remnants of large, old trees that survived the early logging activity in the Sierra Nevada. The least variable habitat type, in terms of size, was MDCF. Note the very low CVs for this type in Tables 5 & 6, compared with other habitat types. In fact, when the acreages of HDCF and MDCF were combined for each bird, the CV of the combined type was only 26.7%, suggesting that most birds tend to include similar amounts of these conifer types in their home ranges. The high CVs of the nonforested habitats suggest that the birds simply include whatever they must of these types when they separate prefered stands of conifer forest.

We found one case of a pair using a home range completely unlike those found in the conifer-forest zone. We first located the Deep Creek pair early in the winter of 1987-88 while tracking a transmittered bird that had migrated downslope and was roosting within 100 m of the Deep Creek pair. The habitat

was oak-pine woodland with interspersed patches of shrubs and grasslands at an elevation of about 1700 ft (520 m). The site was in a deep ravine with perennial water and a well-shaded, north-facing slope. The large accumulation of pellets beneath the roost tree suggested that the pair had used the roost site for a long period of time, probably extending back into the breeding period. Furthermore, the fact that these birds were roosting together was unlike the pattern for migrants, as none of our known migrants had traveled together or even to the same winter home ranges.

This pair was eventually captured and radioed, and they remained throughout the breeding season of 1988 in their low-elevation, oak-pine habitat but did not breed. We were unable to obtain many locations on them, because their home range was so disjunct from those in our main study area. However, this case raises the possibility that other pairs establish permanent home ranges in this sort of habitat, because similarly moist, well-shaded ravines occur commonly along the western foothills of the Sierra Nevada. For example, another male was located in a similar ravine within 1/2-mile of the Deep Creek pair when the Deep Creek Female spent a few days during the summer period in his home range.

Table 1. Home-range sizes (acres) of spotted owls on the Sierra National Forest. Estimates in parentheses were based on insufficient sample sizes or data from a limited part of the sample period. The same applies to data in brackets, which were not used when determining means or medians. Dashes designate records for which available data were insufficient to estimate a home-range size.

Bird	Status[1]	Full year	n	Summer 1987	n	Winter 87-88	n	Summer 1988	n	Winter 88-89	n
Bear Creek Female 1	Enlarger	6477	110					(5122)	70	[3584]	40
Deep Creek Female 1	Resident	----	6								
Deep Creek Male 1	Resident	----	28								
Dinkey Female 1	Migrant			4517	127	----	49				
Dinkey Male 1	Unknown			----	31						
Dinkey Male 2	Migrant			3648	112	----	99	[4605]	28		
Exchequer Female 1	Resident	3845	209	1951	111	3347	98				
Exchequer Male 1	Resident	3349	210	2292	115	2292	95				
Laurel Female 1	Resident							2233	94		
Laurel Male 1	Migrant			2767	129	----	66				
Laurel Male 2	Resident							4130	119	(3967)	52
Markwood Female 1	Unknown	----	46	----	14	----	14	----	18		
Markwood Female 2	Shifter							(2558)	56	[2866]	14
Markwood Male 1	Shifter	6950	248	1956	149	6177	99				
Providence Female 1	Enlarger	7782	400	1395	111	7782	105	2112	133	(2401)	51
Providence Male 1	Resident	2861	186	2368	103	1900	83				
Reese Creek Male 1	Resident	3168	158					1819	134	----	24
Stevenson Female 1	Migrant			[3414]	41	----	90	6842	118	----	52
Stevenson Male 1	Shifter	15713	169	[1649]	43	10373	88	[816]	37		
Strawberry Female 1	Migrant							1819	101	----	33
Strawberry Male 1	Resident	4708	345	(1569)	136	4018	94	2072	119		

[1] Residents remain in basically the same home range all year; enlargers stay in the same general area all year but enlarge the winter home range to include the summer home range; shifters shift the winter territory so that only a portion overlaps with the summer home range; migrants occupy distinctly different summer and winter home ranges, the latter always at lower elevations in oak-pine woodlands.

Table 2. Summary statistics on home-range sizes (acres), by season and year. Results for winter 88-89 are based on inadequate samples (records only through 31 December 1988).

	Full year	Summer 1987	Winter 87-88	Summer 1988	Winter 88-89
Mean	6095 (9)[1]	2496 (9)	5127 (7)	3190 (9)	3184 (2)
SD	4028	1013	3123	1783	1107
Median	4708	2368	4018	2233	3049

[1] Sample size in parentheses.

Table 3. Summer home-range sizes (acres) of pairs of spotted owls on the Sierra National Forest to show the extent of overlap between members of pairs. The "summer" period--1 March to 30 September--corresponds approximately to the period during which the birds would be nesting and caring for dependent young. Asterisked estimates are judged to be based on inadequate sample sizes but were used to compute means (which may, therefore, be slight underestimates). Median values are underlined.

Pair	Year	Male	n	Female	n	Area shared	Combined total
Dinkey	1987	3648	112	4517	127	2585	5528
Exchequer	1987	2292	115	1951	111	1612	2611
Laurel	1988	4130	119	2233	94	1691	4642
Providence	1987	2368	103	1395	111	971	2796
Stevenson	1987	1649*	43	3414*	41	1290	3770
Stevenson	1988	816*	37	6842	118	791	6867
Strawberry	1988	2072	119	1819	101	1358	2500
Mean		2425		3167		1497	4102
SD		1136		1945		555	1662

Table 4. Diets of spotted owls in the Sierra National Forest. This reports analyses of 272 pellets from high-elevation sites in summer and 48 pellets from low-elevation sites in winter. Percentages show the proportion of individual prey items by taxon (mammals, birds, insects).

	High elevation		Low elevation	
Prey type	Summer	Winter	Summer	Winter
MAMMALS	521 (49%)			68 (93%)
Glaucomys sabrinus	180			0
Thomomys spp.	118			1
Peromyscus spp.	103			7
Neotoma spp.	9			53
Eutamias spp.	30			0
Scapanus latimanus	28			1
Sorex spp.	26			2
Microtus spp.	16			1
Other rodents	32			3
BIRDS	159 (15%)			1 (2%)
INSECTS	368 (35%)			4 (5%)
Coleoptera	175			2
Homoptera	98			0
Heterocera[1]	??			

[1] Owls were observed capturing these insects, although none was found in any pellet.

Table 5. Comparison of the acres (Area) of habitat types available with the number of owl locations (Obs) in each type in 1987.

	Habitat types													
	High-Density Conifer Forest		Mid-Density Conifer Forest		Low-Density Conifer Forest		Meadow		Shrubfield		Rock Outcrop		Shrub/Rock	
Bird	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs
Dinkey Female 1	177	25	2278	55	47	7	0	0	203	3	1177	22	707	9
Dinkey Male 2	102	2	2046	50	95	9	5	0	197	0	224	3	757	14
Exchequer Female 1	349	47	1325	48	35	0	7	0	0	0	210	2	23	1
Exchequer Male 1	424	49	1506	50	122	2	46	1	0	0	207	1	6	1
Laurel Male 1	99	1	1902	95	261	4	158	9	23	0	399	5	0	0
Markwood Male 1	354	54	872	62	0	0	26	1	514	18	129	2	38	0
Providence Female 1	14	0	1143	99	0	0	53	0	211	6	0	0	0	0
Providence Male 1	338	12	1643	77	11	9	42	0	245	3	76	2	10	1
Stevenson Female 1	540	12	1209	13	157	0	120	1	606	7	679	4	64	1
Stevenson Male 1	508	26	512	12	8	0	0	0	144	3	404	3	63	0
Strawberry Male 1	142	11	1245	100	53	3	56	0	0	0	74	0	0	0
Mean	277		1426		72		47		195		325		152	
SD	179		520		82		51		205		342		288	
Percent CV	64		36		114		110		105		105		190	

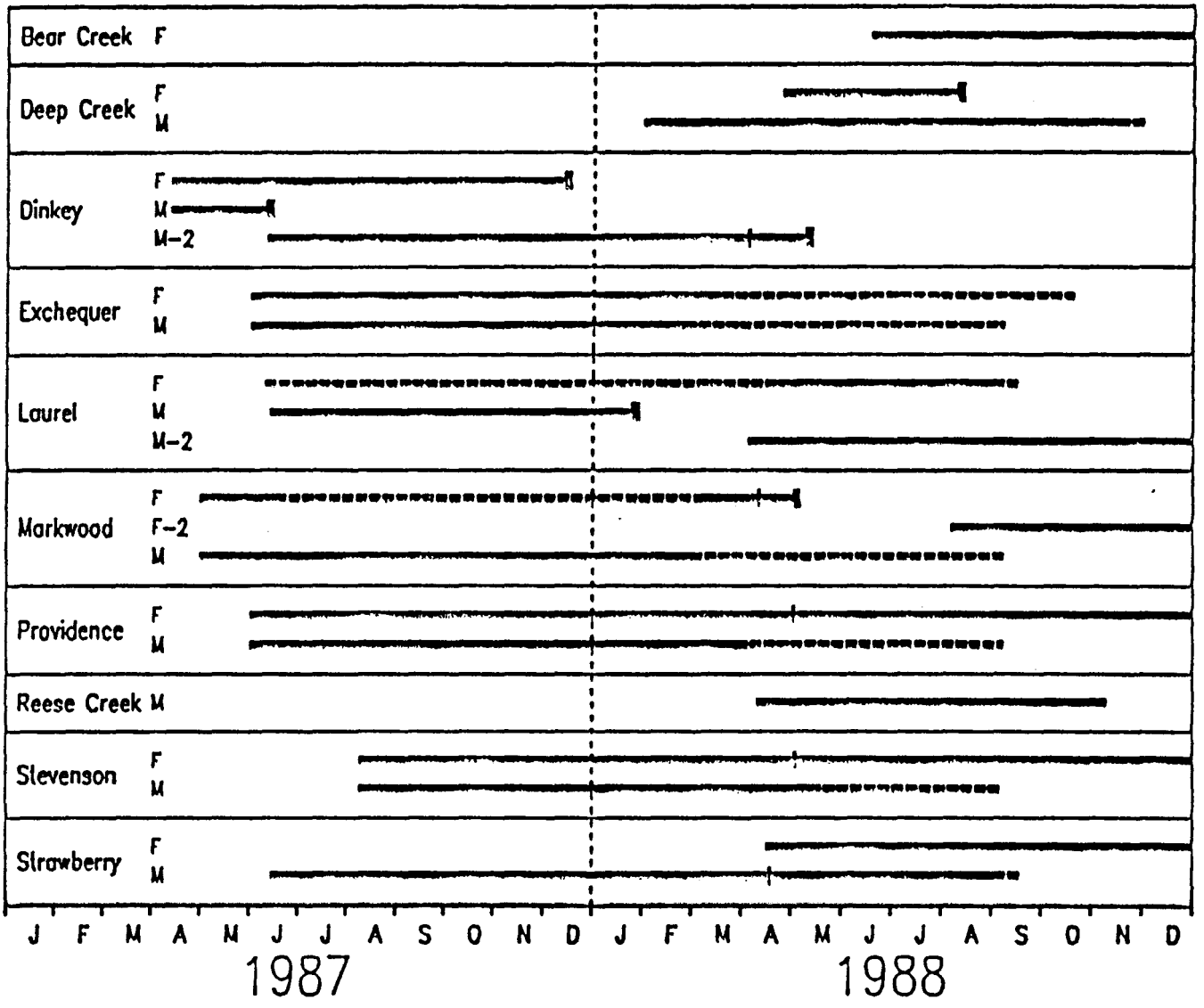
Table 6. Comparison by percentages of the areas of habitat types available with the number of owl locations (Obs) in each type in 1987, as a measure of habitat preference, showing chi-square values and probability levels for each bird. When the percentage in the "Area" column exceeds the value in the "Obs" column, it suggests avoidance of a habitat type. When the percentage in the "Area" column is less than that in the "Obs" column, it suggests preference for that habitat type.

	Habitat types															
	High-Density Conifer Forest		Mid-Density Conifer Forest		Low-Density Conifer Forest		Meadow		Shrubfield		Rock Outcrop		Shrub/Rock			
Bird	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Chi square	P
Dinkey Female 1	3.9	20.7	49.6	45.5	1.0	5.8	0	0	4.4	2.4	25.7	18.2	15.4	7.4	109.87	<0.005
Dinkey Male 2	3.0	2.6	59.7	64.1	2.8	11.5	0.2	0	5.8	0	6.5	3.9	22.1	18.0	26.08	<0.005
Exchequer Female 1	17.9	48.0	68.0	49.0	1.8	0	0.4	0	0	0	10.8	2.0	1.2	1.0	57.59	<0.005
Exchequer Male 1	18.4	47.1	65.2	48.1	5.3	1.9	2.0	1.0	0	0	9.0	1.0	0.3	1.0	58.37	<0.005
Laurel Male 1	3.5	0.9	65.9	83.3	9.2	3.5	5.6	7.9	0.8	0	14.0	4.4	0	0	19.98	<0.005
Markwood Male 1	18.3	39.4	45.1	45.3	0	0	13.5	0.7	26.6	13.1	6.7	1.5	2.0	0	46.47	<0.005
Providence Female 1	1.0	0	80.5	94.3	0	0	3.7	0	14.8	5.7	0	0	0	0	12.90	<0.005
Providence Male 1	14.3	11.5	69.5	74.0	0.5	8.7	1.8	0	10.4	2.9	3.2	1.9	0.4	1.0	91.86	<0.005
Stevenson Female 1	16.0	31.6	35.8	34.2	4.7	0	3.6	2.6	18.0	18.4	20.1	10.5	1.9	2.5	9.36	0.2-0.1
Stevenson Male 1	31.0	59.1	31.2	27.3	0.5	0	0	0	8.8	6.8	24.7	6.8	3.8	0	18.08	<0.005
Strawberry Male 1	9.0	9.7	79.3	87.7	3.4	2.6	3.4	0	0	0	4.7	0	0	0	10.60	0.05-0.02
Mean	12.4	24.6	59.2	59.3	2.7	3.1	3.1	1.1	8.1	4.5	11.4	4.6	4.3	2.8		
SD	9.2	21.4	16.6	22.6	2.9	4.0	3.9	2.4	8.7	6.2	8.7	5.5	7.4	5.5		
Percent CV	74.1	86.9	28.1	38.2	105.7	123.7	125.8	217.3	107.6	137.4	76.4	119.9	172.1	196.0		

FIGURE 1. Bar graphs depicting time periods during which spotted owls carried active and inactive radio transmitters.

Figure 1

RADIO TRACKING ACTIVITY FOR SIERRA NF SPOTTED OWLS



Periods in which owls were radio tracked.

Based on visual locations (banded or nonworking Xmitter).

Indicates death of this individual.

Indicates replacement of Xmitter.

FIGURE 2. Known and probable home ranges of individual birds (narrow lines and dashes) and composite area occupied (thick dashed line). Solid lines designate 1988 home-range boundaries of birds with active transmitters. Narrow dashed lines designate probable home-range boundaries of birds with inactive transmitters. The boundaries shown in these cases were based on measured home ranges using transmitter locations in 1987; all birds involved were seen regularly during 1988 within the same home-range areas.

Figure 2

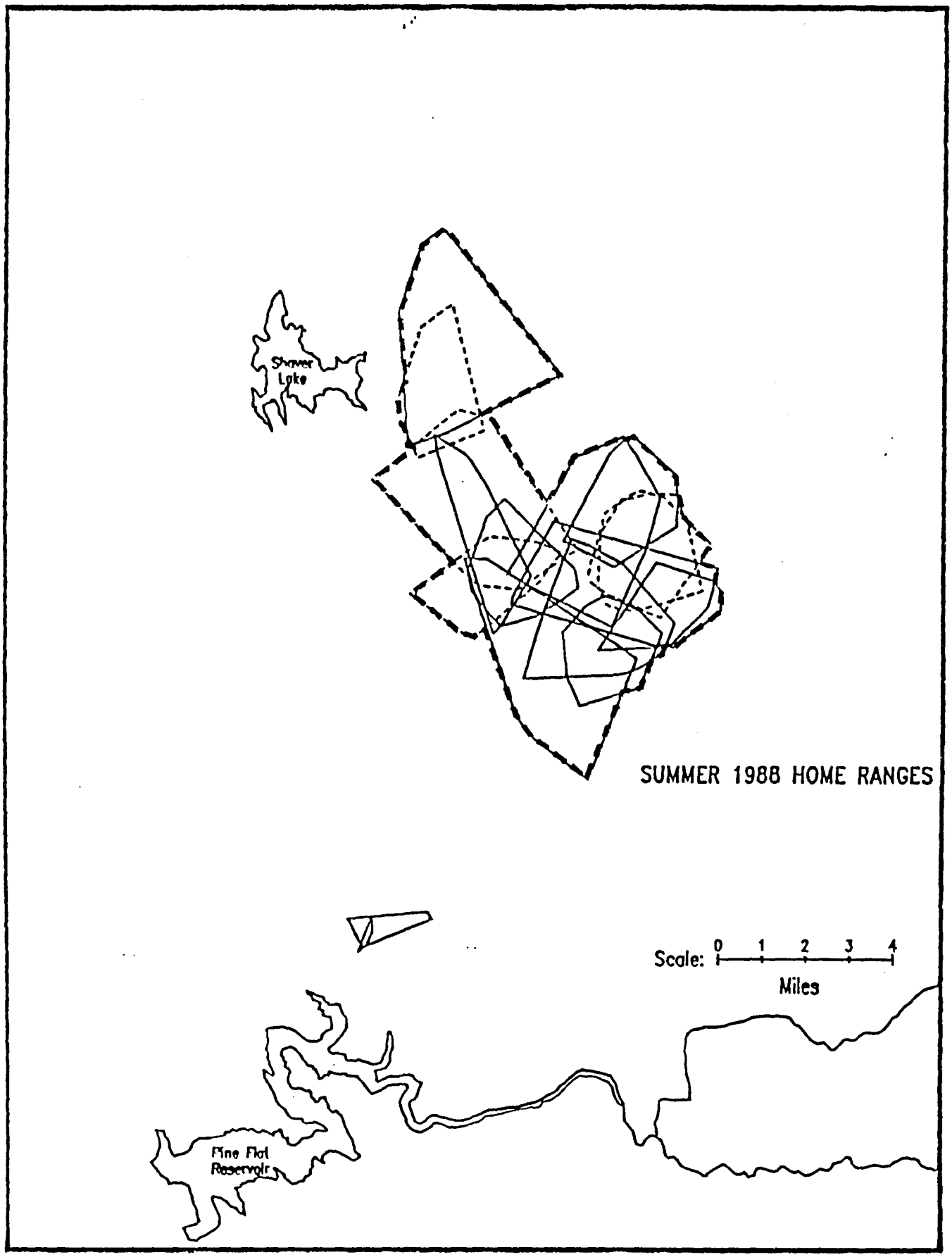

Shaver Lake
SUMMER 1988 HOME RANGES
Scale: 0 1 2 3 4
Miles
Pine Flat Reservoir

FIGURE 3. Nearly full-year home range of Exchequer Male 1, depicting a permanent resident that used essentially the same home range during all seasons.

Sierra National Forest

FIGURE 4. Nearly full-year home range of Exchequer Female 1 depicting a permanent resident that used essentially the same home range during all seasons. This bird and her mate (see Fig. 3) had nearly identical home ranges, neither migrated, and their home ranges were at the highest elevation of all pairs (mean elevation = 6400 ft.).

Figure 4

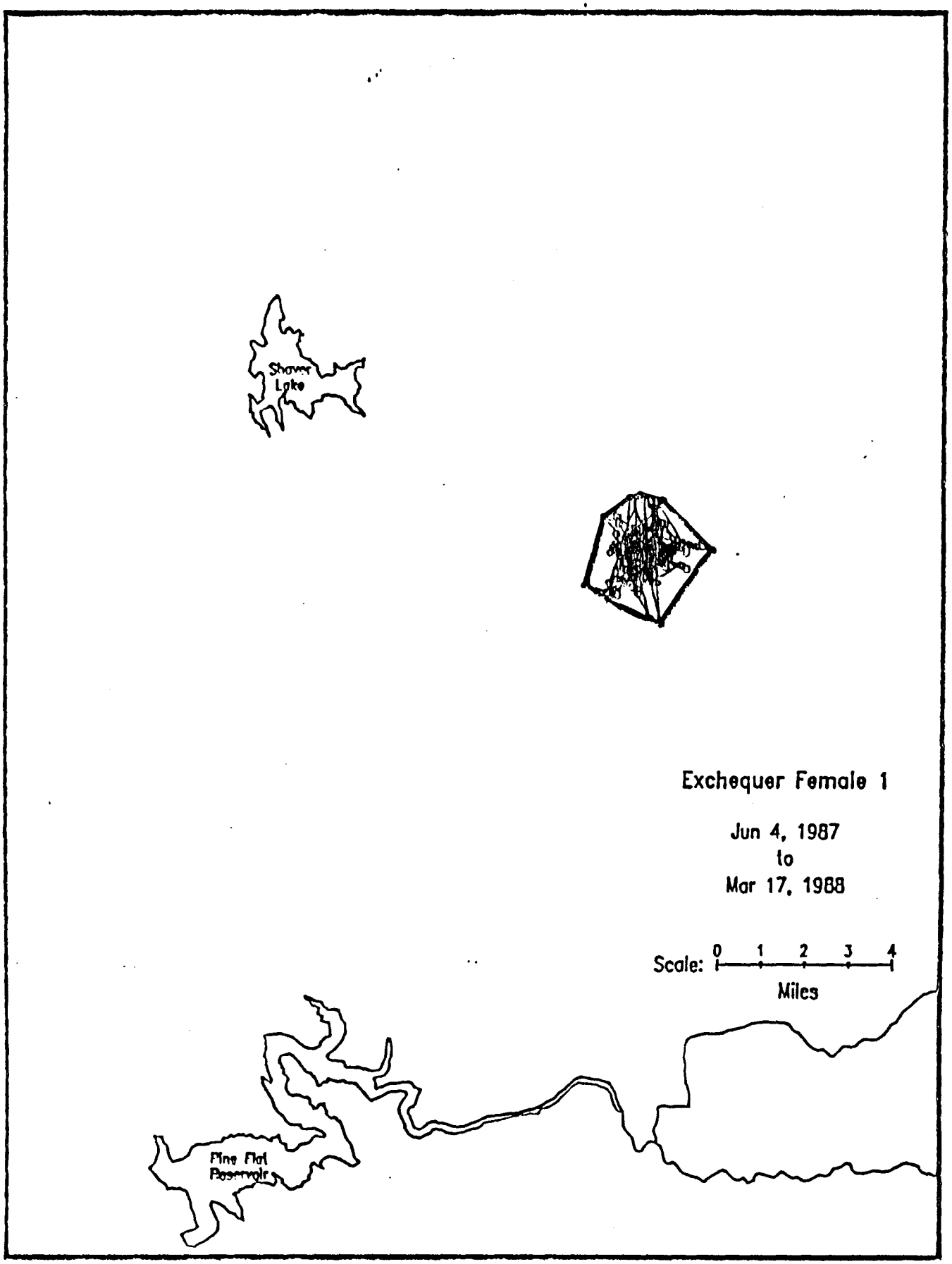
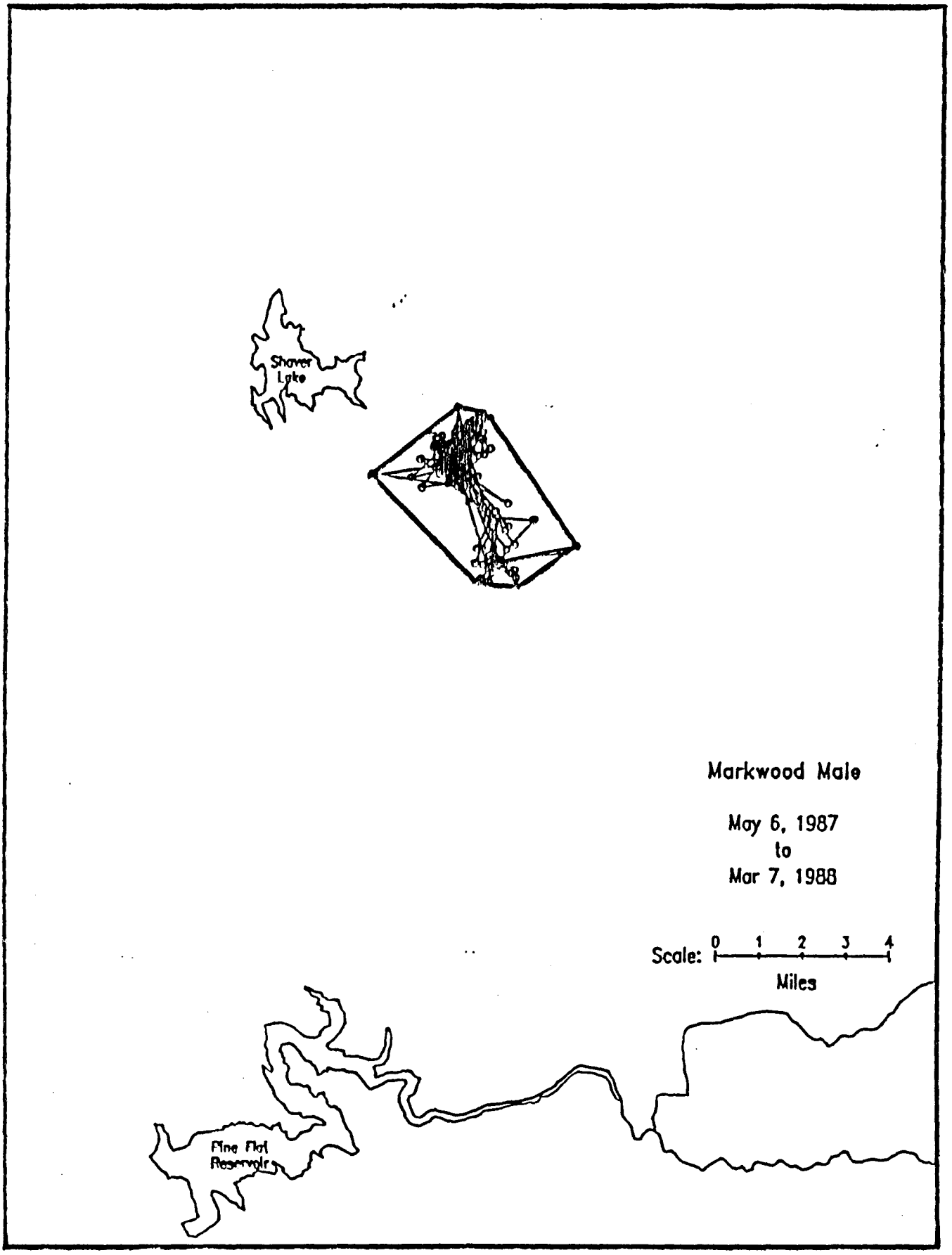

Shaver Lake
Exchequer Female 1
Jun 4, 1987
to
Mar 17, 1988
Scale: 0 1 2 3 4
Miles
Pine Flat Reservoir

FIGURE 5. Nearly full-year home range of the Markwood Male, another permanent resident.

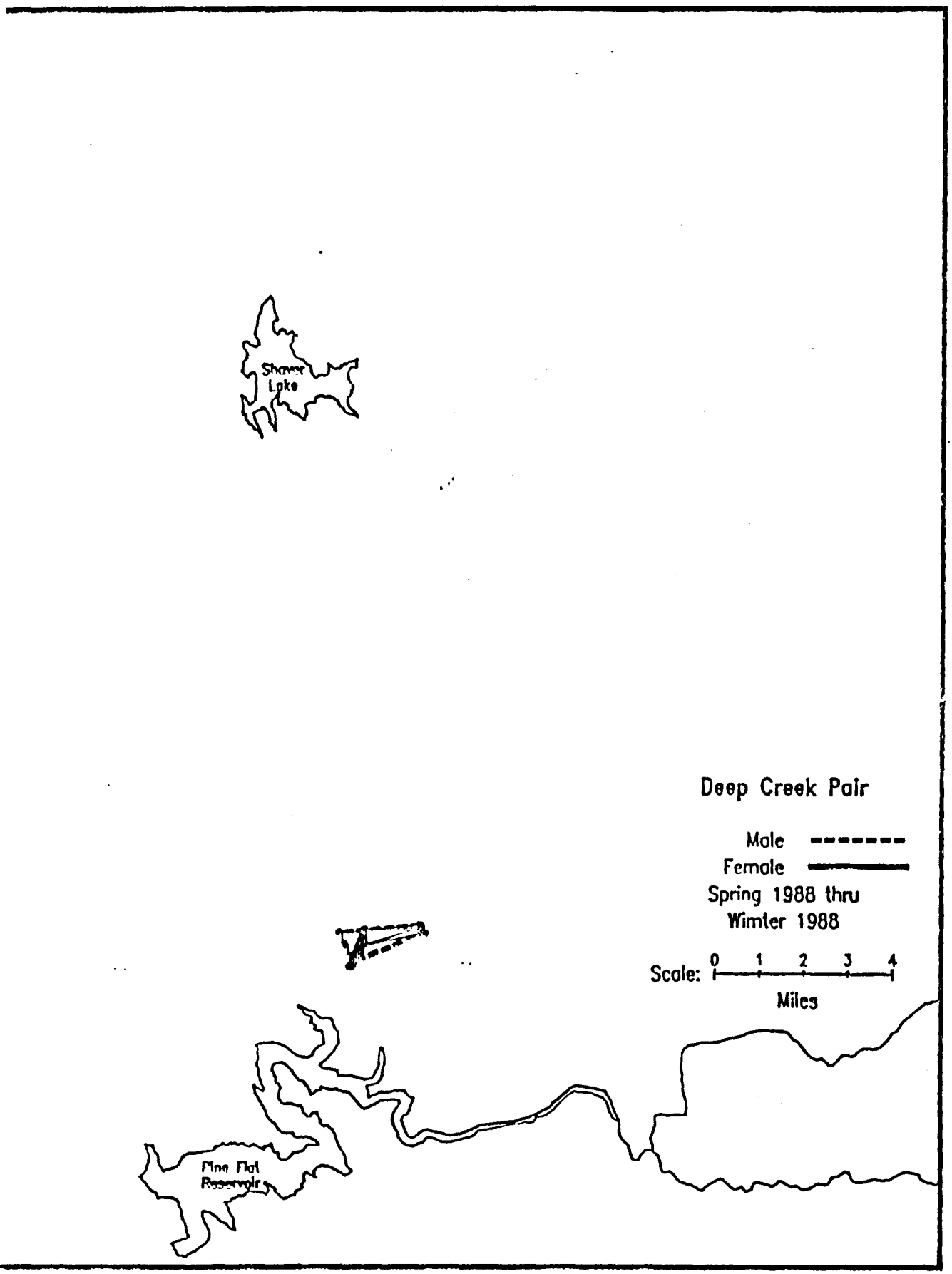
Figure 5


Shaver Lake
Markwood Male
May 6, 1987
to
Mar 7, 1988
Scale: 0 1 2 3 4
Miles
Pine Flat Reservoir

Sierra National Forest

FIGURE 6. Probable year-round home range of the Deep Creek Pair, still further examples of permanent residents. The figure is based on occasional radio-tracking records from spring 1988 through 31 December 1988, although the birds were observed several times in the same area during the winter of 1987-88, before they were captured and radio-tagged in the spring of 1988. This home range is at an elevation of about 1000 ft. in oak-pine woodlands with interspersed shrub- and grasslands.

Figure 6


Shaver Lake
Deep Creek Pair
Male
Female
Spring 1988 thru
Winter 1988
Scale: 0 1 2 3 4
Miles
Pine Flat Reservoir

Sierra National Forest

FIGURE 7. Summer and winter home ranges of the Providence Female, the only bird to exhibit seasonal shifts in home range that we refer to as an "enlarger." During the winter of 1987-88 she enlarged her home range compared to the summer of 1987, but she continued to use all of the summer area during that winter as well. So far during the winter of 1988-89, she has not enlarged her home range compared to the summer of 1988.

Figure 7

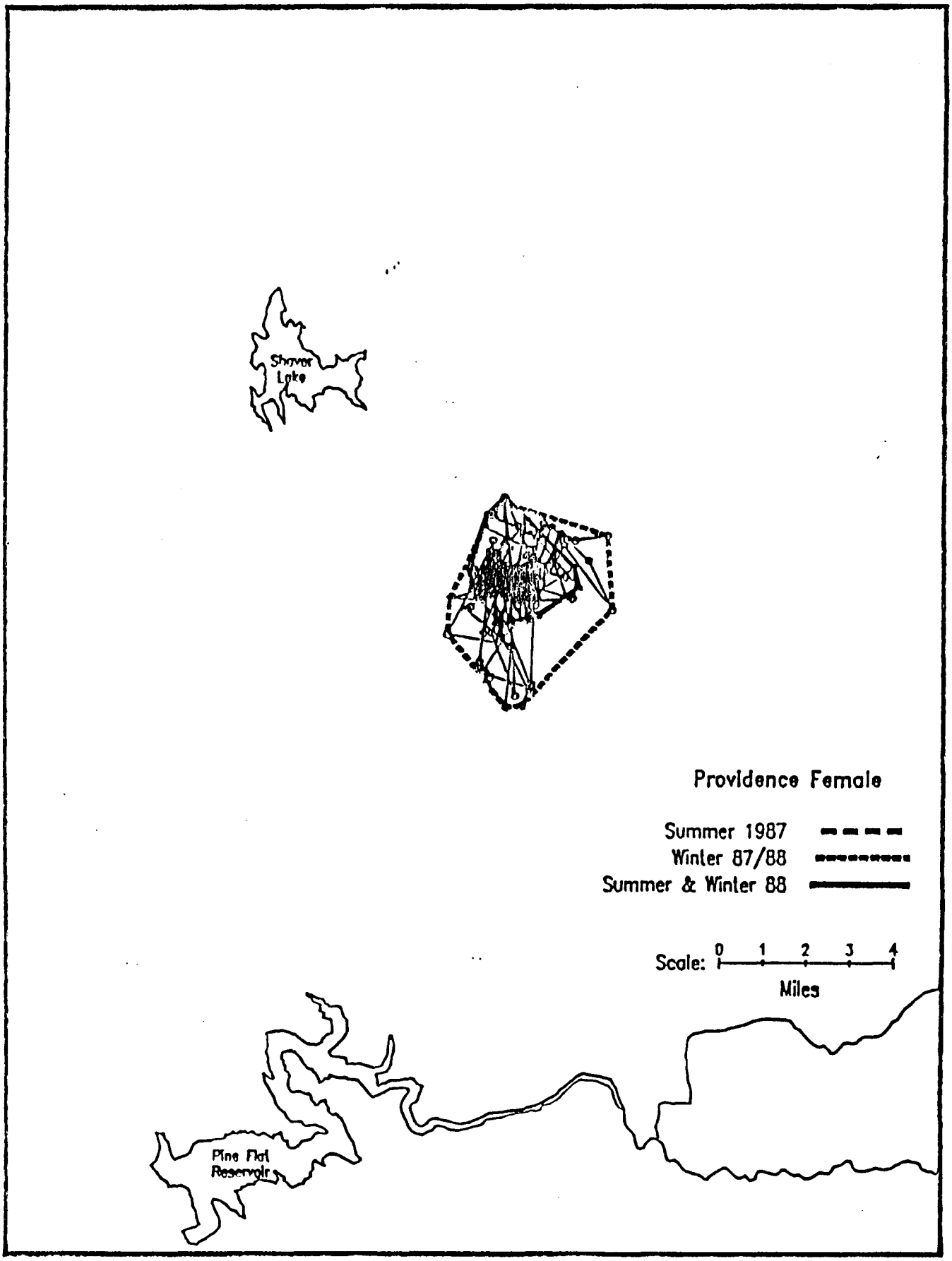

Shaver Lake
Providence Female
Summer 1987
Winter 87/88
Summer & Winter 88
Scale: 0 1 2 3 4
Miles
Pine Flat Reservoir

FIGURE 8. Summer and winter home ranges of Markwood Female 2, a bird we refer to as a "slider." Although she used some of the same area between winter and summer periods, she nonetheless exhibited a distinct downslope shift in home range during the winter.

Figure 8

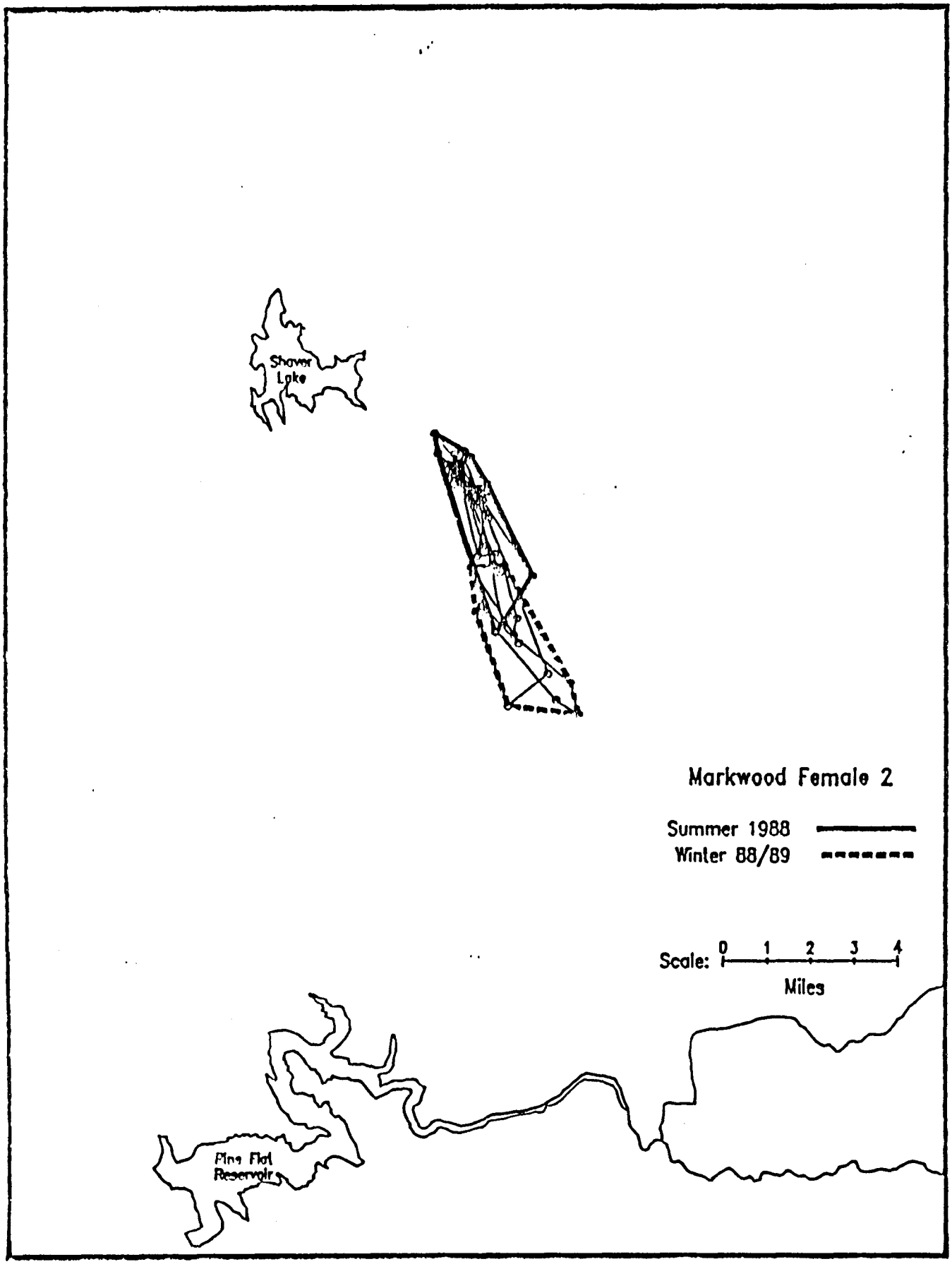

Shaver Lake
Markwood Female 2
Summer 1988
Winter 88/89
Scale: 0 1 2 3 4
Miles
Pine Flat Reservoir

FIGURE 9. Summer and winter home ranges of Stevenson Male 1. This is another example of a "slider," a bird that shifts its home range downslope in winter but whose summer and winter home ranges overlap.

Figure 9

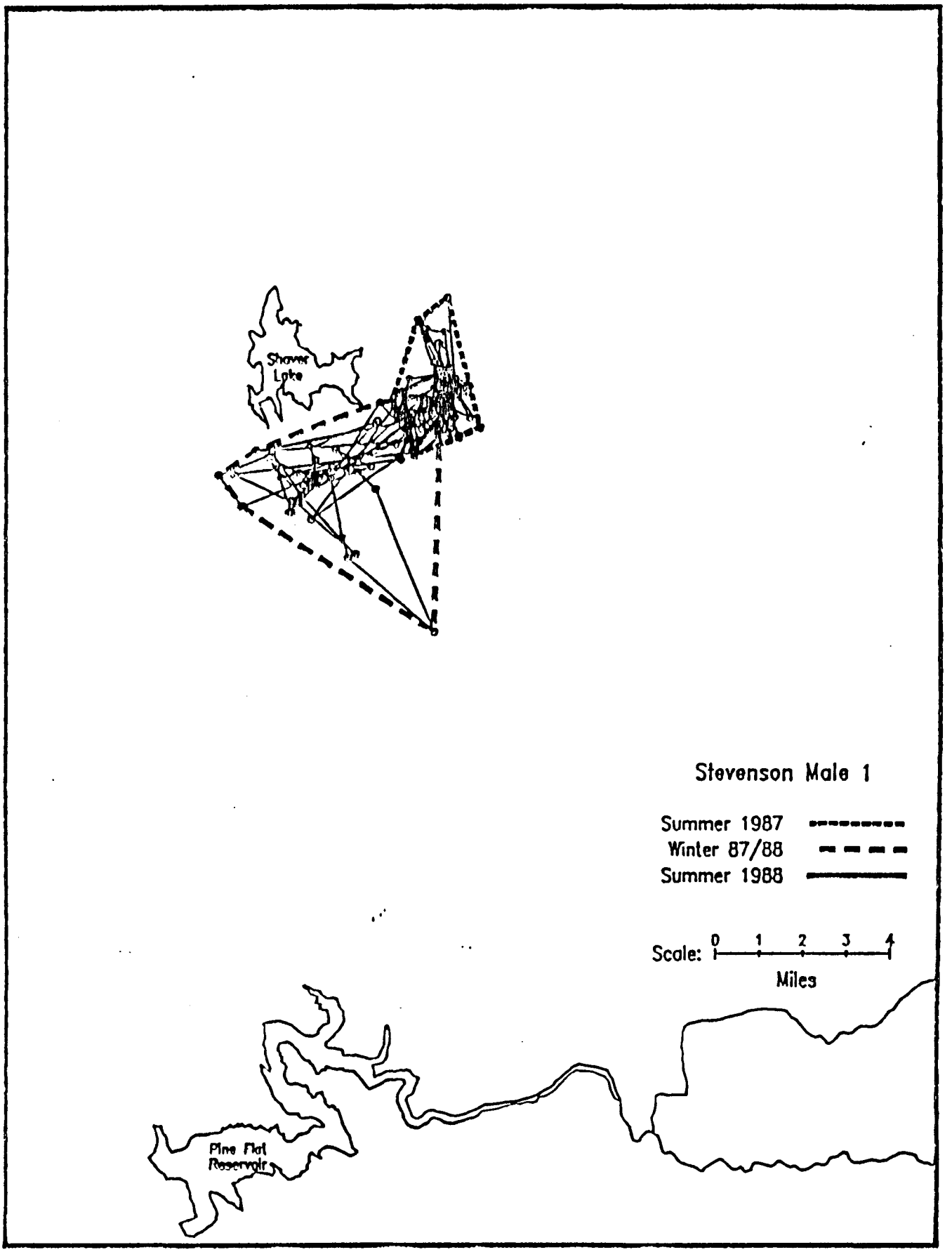
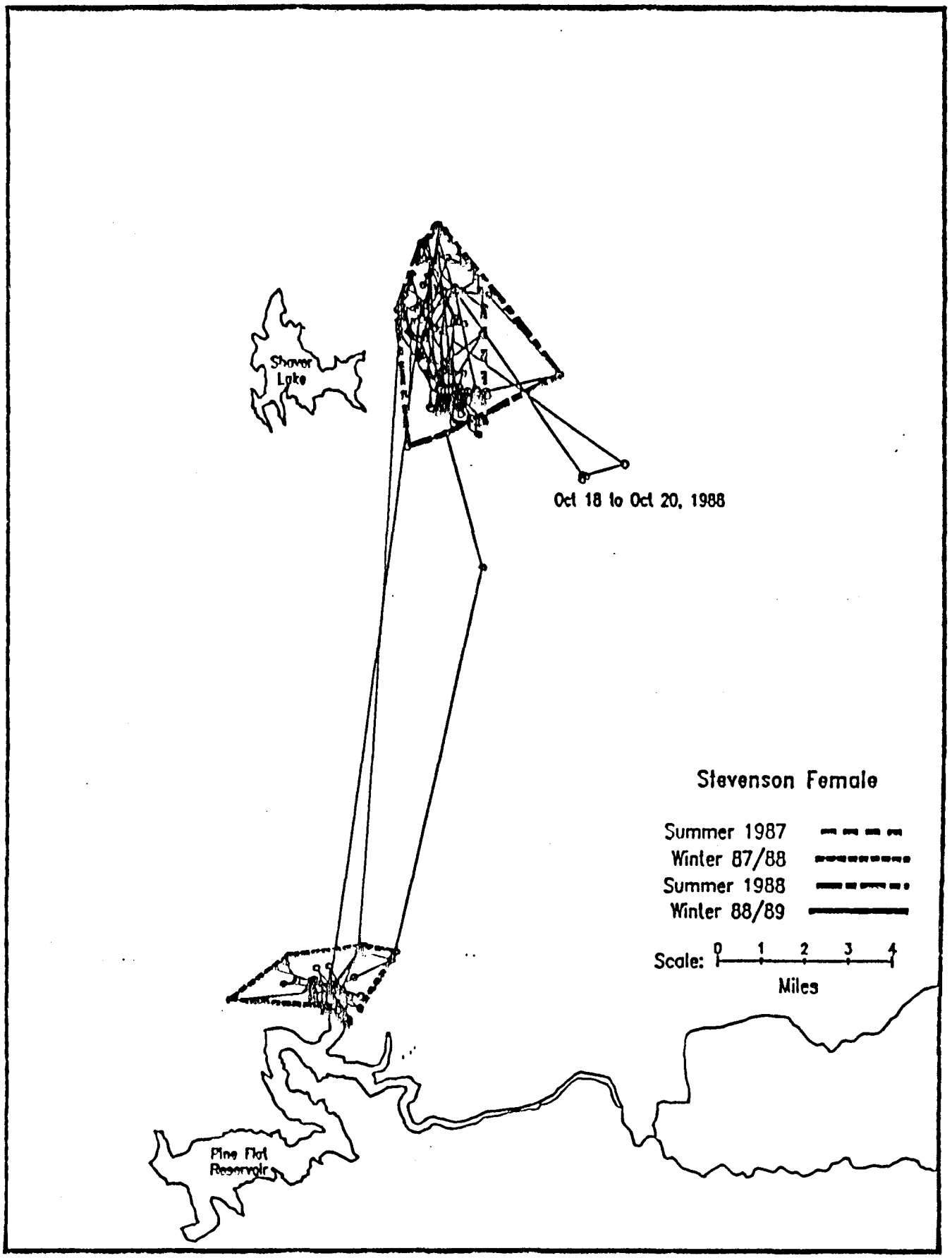

Shaver Lake
Stevenson Male 1
Summer 1987
Winter 87/88
Summer 1988
Scale: 0 1 2 3 4
Miles
Pine Flat Reservoir

FIGURE 10. Summer and winter home ranges of the Stevenson Female, a typical altitudinal migrant with disjunct summer and winter home ranges. This is one of few such birds for which we have sufficient winter locations to estimate home-range size during that period.

Figure 10


Shaver Lake
Oct 18 to Oct 20, 1988
Stevenson Female
Summer 1987
Winter 87/88
Summer 1988
Winter 88/89
Scale: 0 1 2 3 4
Miles
Pine Flat Reservoir

Sierra National Forest

FIGURE 11. Summer and partial winter home range of the Strawberry Female, a typical altitudinal migrant.

Figure 11

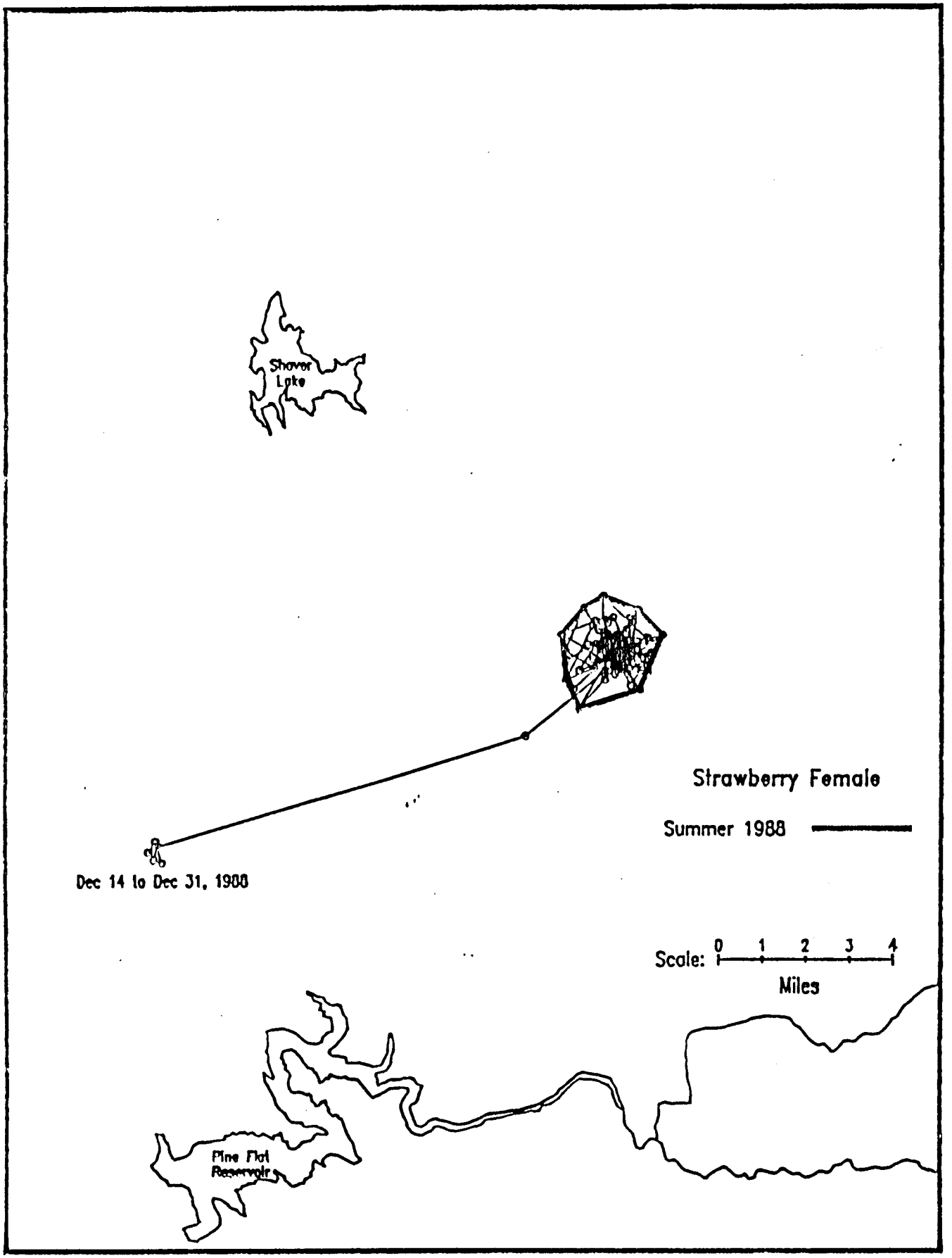

Shaver Lake
Strawberry Female
Summer 1988
Dec 14 to Dec 31, 1988
Scale: 0 1 2 3 4
Miles
Pine Flat Reservoir

FIGURE 12 (A through H). Combined home ranges of pairs showing the extent of overlap. Compare figures with results in Table 3.